

Applicant: Thomas BUCHBERGER et al.
Docket No. R.304929
Preliminary Amdt.

AMENDMENTS TO THE SPECIFICATION:

Page 1, please add the following new paragraphs before paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 USC 371 application of PCT/DE 03/03300 filed on October 6, 2003.

Please replace paragraph [0001] with the following amended paragraph:

[0001] Background of the Invention **BACKGROUND OF THE INVENTION**

Please add the following new paragraph after paragraph [0001]:

[0001.5] Field of the Invention

Please replace paragraph [0002] with the following amended paragraph:

[0002] The invention relates to a pressure limiting valve ~~as generically defined by the preamble to claim 1~~ and more particularly to an improved pressure limiting valve suitable for use fuel injection systems.

Please add the following new paragraph after paragraph [0002]:

[0002.5] Description of the Prior Art

Please replace paragraph [0003] with the following amended paragraph:

[0003] A pressure limiting valve in conjunction with a device for injecting fuel, in particular Diesel fuel, is known from the book entitled Diesel-engine Management, Stuttgart 1999, page 273 (ISBN 0-7680-0509-4). A pressure limiting valve of this type serves to limit pressure yet at the same time furnish an emergency operation capability property. Preferably, the pressure limiting valve of this type is used in conjunction with common rail systems.

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Please replace paragraph [0005] with the following amended paragraph:

[0005] Summary of the Invention **SUMMARY OF THE INVENTION**

Please replace paragraph [0006] with the following amended paragraph:

[0006] The pressure limiting valve **of the invention** is distinguished by having only a few parts, which can also be produced economically. Because of the separation provided according to the invention between the spring washer and the piston, the possibility also exists of adjusting the opening pressure in a simple way and compensating for production variations. Moreover, the invention offers the advantage in particular that even at a comparatively low pump rpm and a slight flow rate, stable emergency operation is made possible. A pressure curve is furnished that is virtually independent of the flow rate. The pressure limiting valve equipped according to the invention is furthermore distinguished by having only a very small size. This makes it possible to install it into component groups of the injection system, such as a rail or pump, in which only little installation space is available. Because of the flat places provided on the piston of the pressure limiting valve, an adequate flow cross section for major pump feeding quantities is furnished.

Page 2, please replace paragraph [0007] with the following amended paragraph:

[0007] Drawing **BRIEF DESCRIPTION OF THE DRAWINGS**

Please replace paragraph [0008] with the following amended paragraph:

[0008] The invention will be described in detail below, in conjunction with the **drawing**,
drawings, in which:

Please delete paragraph [0009].

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Please replace paragraph [0010] with the following amended paragraph:

[0010] Fig. 1[[],] is a sectional view of a first exemplary embodiment of a pressure limiting valve according to the invention;

Page 3, please replace paragraph [0017] with the following amended paragraph:

[0017] Fig. 8, a further exemplary embodiment of a pressure limiting valve, in which a conically embodied compression spring concentrically surrounds a piston rod that is connected to the piston; and

Please replace paragraph [0018] with the following amended paragraph:

[0018] Fig. 9, a refinement of the exemplary embodiment shown in Fig. 8 [[9]], in which the piston has flat places and/or control edges.

Please replace paragraph [0019] with the following amended paragraph:

[0019] Variant Embodiments **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Please replace paragraph [0020] with the following amended paragraph:

[0020] Fig. 1 shows a first exemplary embodiment of a pressure limiting valve embodied according to the invention that is especially well suited to emergency operation as well. The pressure limiting valve 10 includes a valve holder 1, which is embodied as essentially cup-shaped, and includes two subregions 1a, 1b of different inside diameters D1, D2. The subregions 1a, 1b each extend over part of the total length of the valve holder 1 and merge in steplike fashion with one another. The subregion 1a of the valve holder 1 having the lesser inside diameter D1 is next to the bottom of the valve holder 1. The subregion 1b of the valve holder having the larger inside diameter D2 is oriented toward [[the]] a valve insert 2. The

subregion 1a of the valve holder 1 serves to receive [[the]] a compression spring 5. The subregion 1b of the valve holder 1 embraces the valve insert 2 from outside and establishes the connection between these two parts. Preferably, the valve insert 2 is calked to the valve holder. This type of fastening can be done economically on a mass-production scale and has proven itself to be sufficiently reliable. Alternatively, however, it is also conceivable to provide the valve holder 1 and the valve insert with a suitable thread and to screw the two parts together. This type of connection will not be as economical but on the other hand would offer the advantage of a further degree of freedom for compensating for production variations. That is, by twisting the parts 1, 2 more or less markedly, the prestressing exerted on the compression spring 5 could be varied. A valve piston 3 is slidably supported in a bore disposed centrally in the valve insert. Between the compression spring 5 and the valve piston 3, an adjusting shim 4 is disposed such that the compression spring 5, resting in the subregion 1a of the valve holder, is braced on one end on the bottom of the valve holder 1 and on the other on the side face, remote from the valve piston, of the adjusting shim 4. The compression spring 5 acts on the valve piston 3 in the closing direction indirectly via the adjusting shim. The adjusting shim 4 itself is slidably supported in a cup-shaped recess 2a disposed in the valve insert 2. Upon an opening or closing motion of the valve piston 3, this piston is moved up and down and in the process is guided by the wall of the cup-shaped recess 2a. The steplike transition of the valve holder 1 formed by the different diameter regions (diameters D1, D2) rests on the valve insert 2 and protrudes radially inward. This creates a stop for the adjusting shim 4. When pressure is exerted on the valve piston 3 acting counter to the compression spring 5, the adjusting shim 4 can move at most as far as the stop

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and thus also prevents the valve piston 3 from being lifted excessively far from its seat in the valve insert 2. The adjusting shim 4 has a fluid-passable recess or opening 4a, which is preferably disposed eccentrically in the adjusting shim, in order to assure good bracing of the valve piston 3 on the adjusting shim 4. Through this recess 4a, once the valve piston 3 has lifted from its seat, fuel can flow into the subregion 1a, accommodating the compression spring 5, of the valve holder. At least one outflow conduit 1c is provided in the wall of the valve holder 1 and is expediently embodied as a bore connecting the subregion 1a of the valve holder to its outer jacket face. This outflow conduit 1c is preferably disposed horizontally (Fig. 3). However, as shown in Fig. 1, it may also be let into the wall of the valve holder 1 in such a way that it extends obliquely. That is, the axis A of the outflow conduit 1c and the longitudinal axis A1 of the valve holder are oriented at an angle to one another, specifically and preferably such that an acute is defined between the axis A and the direction of the longitudinal axis of the valve piston 3. A sealing means, preferably an O-ring 6, is also disposed on the outer jacket face of the valve holder 1, resting in a seat. In Fig., a protective cap 7 is also shown, which protects the pressure limiting valve 10 from damage and contamination during storage and while being transported until it is installed.

Page 5, please replace paragraph [0021] with the following amended paragraph:
[0021] The compression spring 5 and the hydraulically active seat diameter, which results from the contacting edge of the valve insert 2 and the valve piston 3, are adapted to one another such that a predetermined opening pressure P1 results. This opening pressure P1 can be adjusted especially advantageously by means of the adjusting shim 4. By means of

adjusting shims 4 of different thickness, unavoidable production variations can be compensated for easily. The simply constructed parts of the pressure limiting valve 10 can be economically produced and kept on hand. The desired pressure for the emergency operation is adapted in a simple way in cooperation between the guide diameter of the valve piston 3 in the valve insert 2 and the diameter of the valve seat. The valve piston 3 has flat places 3a disposed on its outer circumference. In an especially advantageous embodiment of the pressure limiting valve 10, a total of three flat places 3a are provided, which are distributed uniformly over the circumference of the valve piston 3. The limits to usability at high flow rates are set by the cross section of these flat places 3a. The spring force of the compression spring 5 urges the adjusting shim 4 and thus the valve piston 3 in the closing direction. Beyond a defined value of the pressure, the spring force of the compression spring 5 no longer suffices to keep the pressure limiting valve 10 closed. This value for the pressure, called the opening pressure, in a second generation common rail system, is between about 1850 and 1950 bar. This pressure value can be adjusted established in a simple way by means of a suitably dimensioned adjusting shim 4. Once the opening pressure is reached, the valve piston 3 lifts from its seat in the valve insert 2, and a pressure builds up in the chamber enclosed by the valve piston 3 and [[by]] the valve insert 2. Because of the larger hydraulically active surface area, the valve piston slides so far out of the valve insert 2 that the flat places 3a made on the valve piston 3 become operative, and the fuel can flow out via the open cross-sectional areas. Via the flat places or control edges machined into the valve piston 3, the characteristic curve for emergency operation is regulated. Ideally, the pressure limiting valve 10 would not close again until at a flow rate of about 15 liters/hour. Beyond

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the instant of closure, the function of the pressure limiting valve 10 becomes unstable. If the play between the valve piston 3 and the valve insert 2 were increased, then the pressure limiting valve 10 would for instance already close at a flow rate of about 40 liters/hour. As a consequence, at a low rpm of an internal combustion engine with correspondingly low feeding quantities, stable injection would no longer be possible. Pressure limiting valves with a valve piston 3 lacking flat places 3a have the disadvantage that the pressure rises too fast.

Page 7, please replace paragraph [0025] with the following amended paragraph:

[0025] In an advantageous further feature of the invention, a piston does not directly take on the sealing function of the pressure limiting valve 10. Instead, the valve opening is closed by a ball, which in turn is acted upon by a spring-loaded piston. This is illustrated in Fig. 5, which shows a larger detail, in cross section, of a pressure limiting valve designed in this way. A ball 50 is supported in a seat in the valve insert 2 ~~designated by reference numeral 2~~ and thus closes a valve opening 2b. The ball 50 is in turn acted upon a spring-loaded valve piston 3, which presses the ball 50 into its seat.

Please replace paragraph [0027] with the following amended paragraph:

[0027] An advantageous further feature of a pressure limiting valve is shown in Fig. 7. The valve piston 3 slidably supported in the valve insert 2 of the pressure limiting valve 10 has a plurality of flat places 3a, [[3a3]] 3a.3 over its circumference, whose control edges have a variable spacing [different for each control edge] from the end face, toward the compression spring 5, of the valve piston 3. Accordingly, upon motion of the valve piston 3, the flat places 3a, [[3a3]] 3a.3 come into action at different times. This embodiment is possible both

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with flat places that extend parallel to the longitudinal axis of the valve piston 3 and with flat places oriented obliquely to the longitudinal axis of the valve piston 3.

Page 8, please replace paragraph [0028] with the following amended paragraph:

[0028] In Fig. 8, a further exemplary embodiment of a pressure limiting valve [[20]] designed according to the invention is shown. The even sturdier construction, compared to the exemplary embodiment of Fig. 1, of a pressure limiting valve ~~shows~~ includes a valve piston 3 with a piston rod 3b, which is disposed concentrically to the compression spring 5 and protrudes into the partial chamber 1a of the valve holder 1. The compression spring 5 is embodied as a conical spring and is braced with its larger base on the cup bottom of the valve holder 1. With its smaller base, it rests on an adjusting shim 4, which is slipped onto the piston rod 3b of the valve piston 3 and rests there on a step. However, this pressure limiting valve is not suitable for emergency operation.

Please add the following new paragraph after paragraph [0029]:

[0030] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Please delete page 9.